Albany Research Center

Solutions that make the Nation's energy systems safe, efficient and secure

Design, Construction and Operation of a High Pressure Flow Loop Reactor for Carbon Sequestration

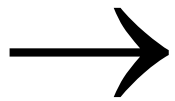
S. J. Gerdemann
L. R. Penner

AIChE Annual Meeting
November 16-21
San Francisco

Carbonation Reactions

$$Mg_2SiO_4 + 2CO_2(g) \rightleftharpoons 2MgCO_3 + SiO_2$$

Olivine



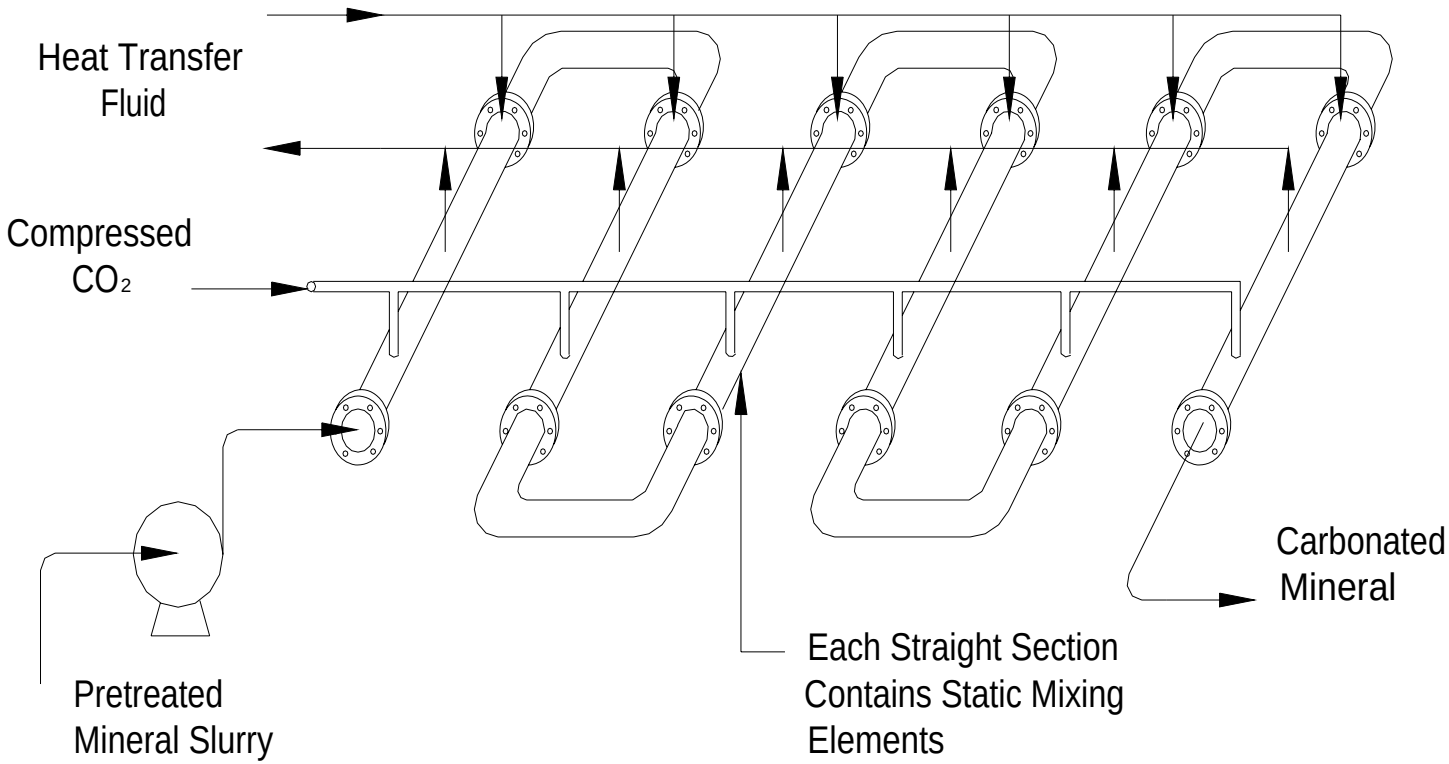
Magnesite

Reaction Conditions

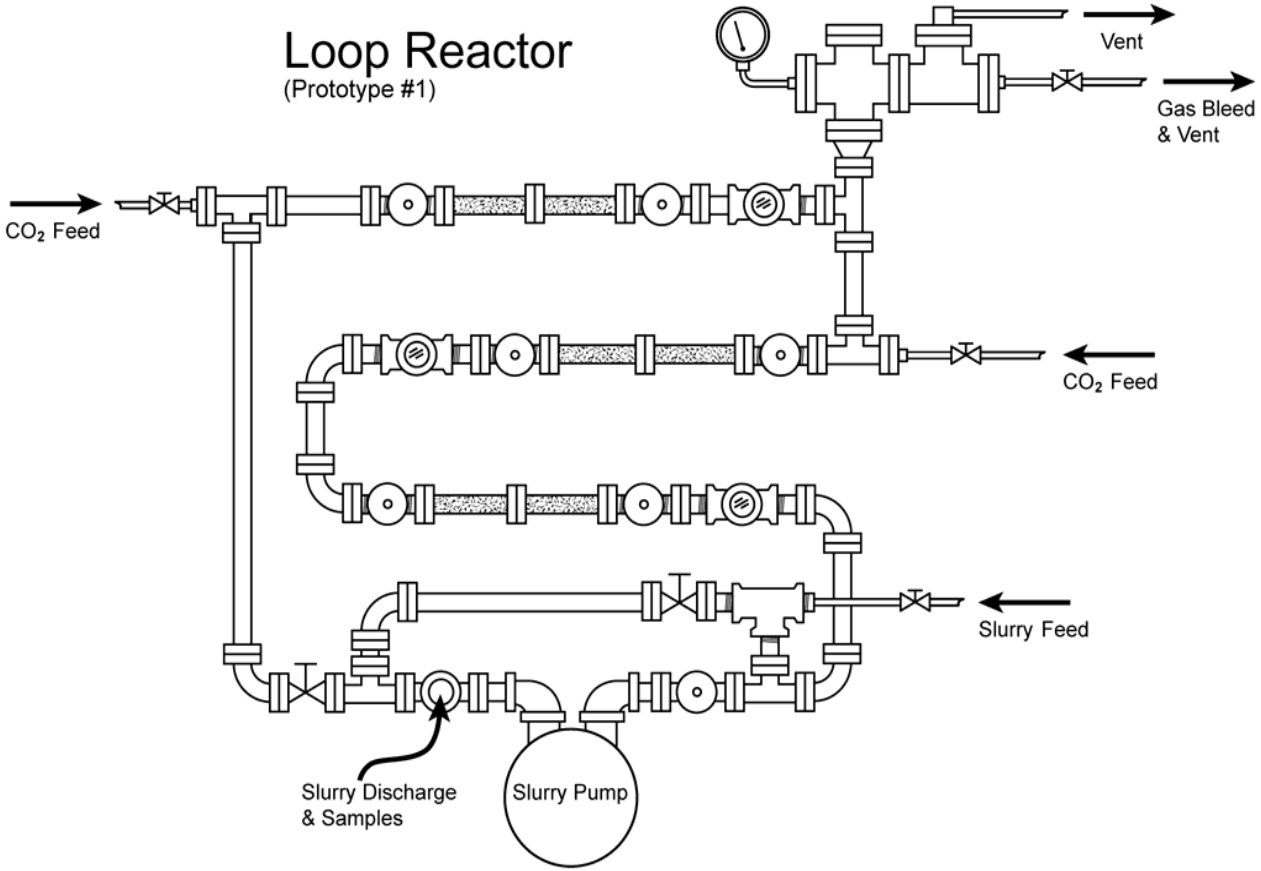
- 3-phase system: Gas/Liquid/Solid
- 1.0 M NaCl & 0.64M $NaHCO_3$ Solution
- 15 – 30 % solids
- 2500 psi
- 200 ^oC

Proposed Conceptual Reactor

(Pipe-Line Flow-Through Reactor)



Loop Reactor



Measurements

- Flow Rate
- System Pressure
- Pressure Differentials
  - Across mixers
  - Across pump
- Temperature
- Extent of Reaction
- Wear and Corrosion

Design Tools

Mixer Test Bench

- Test Bench: Clear PVC tubing with static mixer and instrumented for pressure and flow
  - Component sizing
  - Determine minimum flow rate
  - Observation of flow and mixing
  - Pressure drop data
  - practice in filling and draining system

Mixer

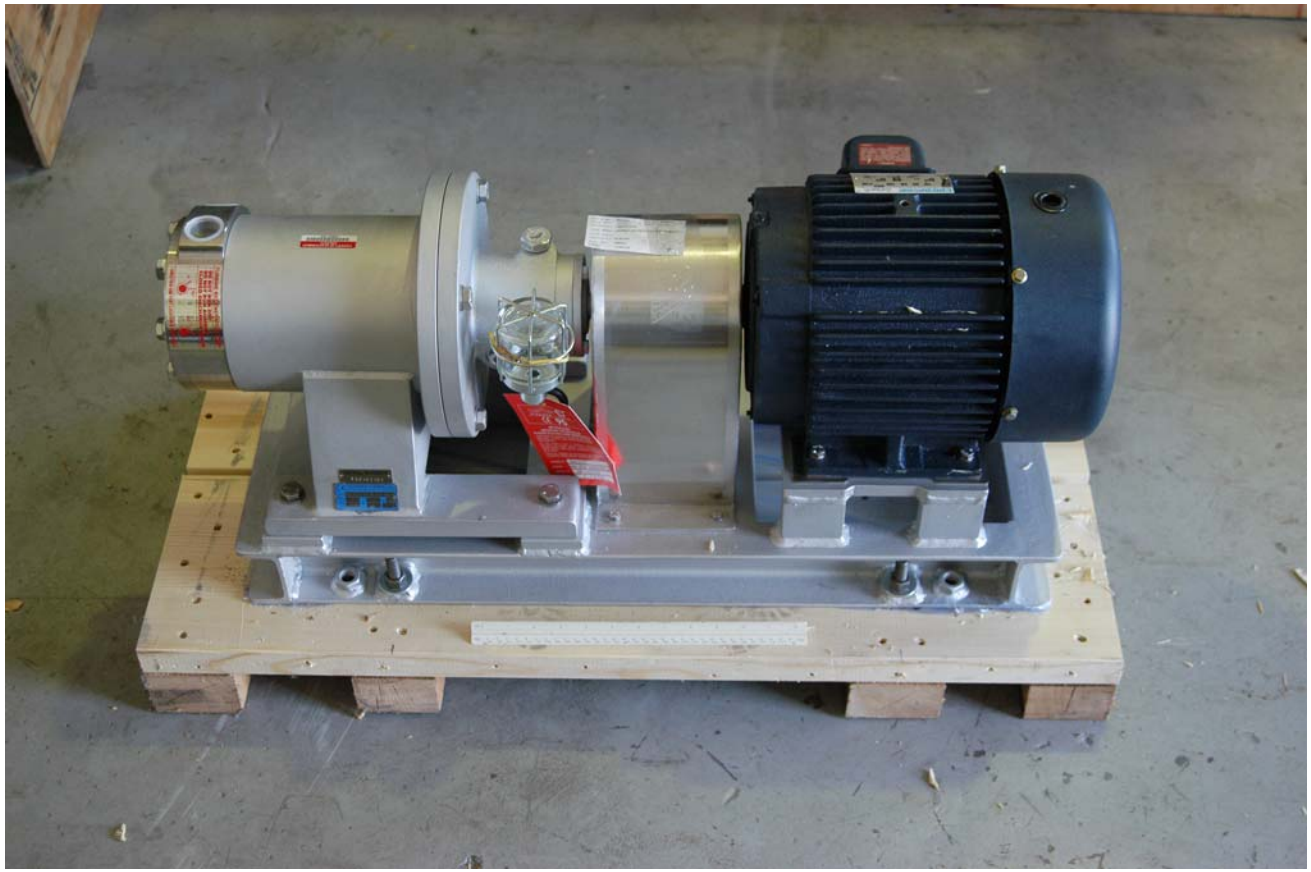
Pump Requirements

- Handle 30% solids
- Handle NaCl/$NaHCO_3$ Solution
- Withstand 2500 psi
- Withstand 200^oC
- Flow rate of 10 to 20 l/m

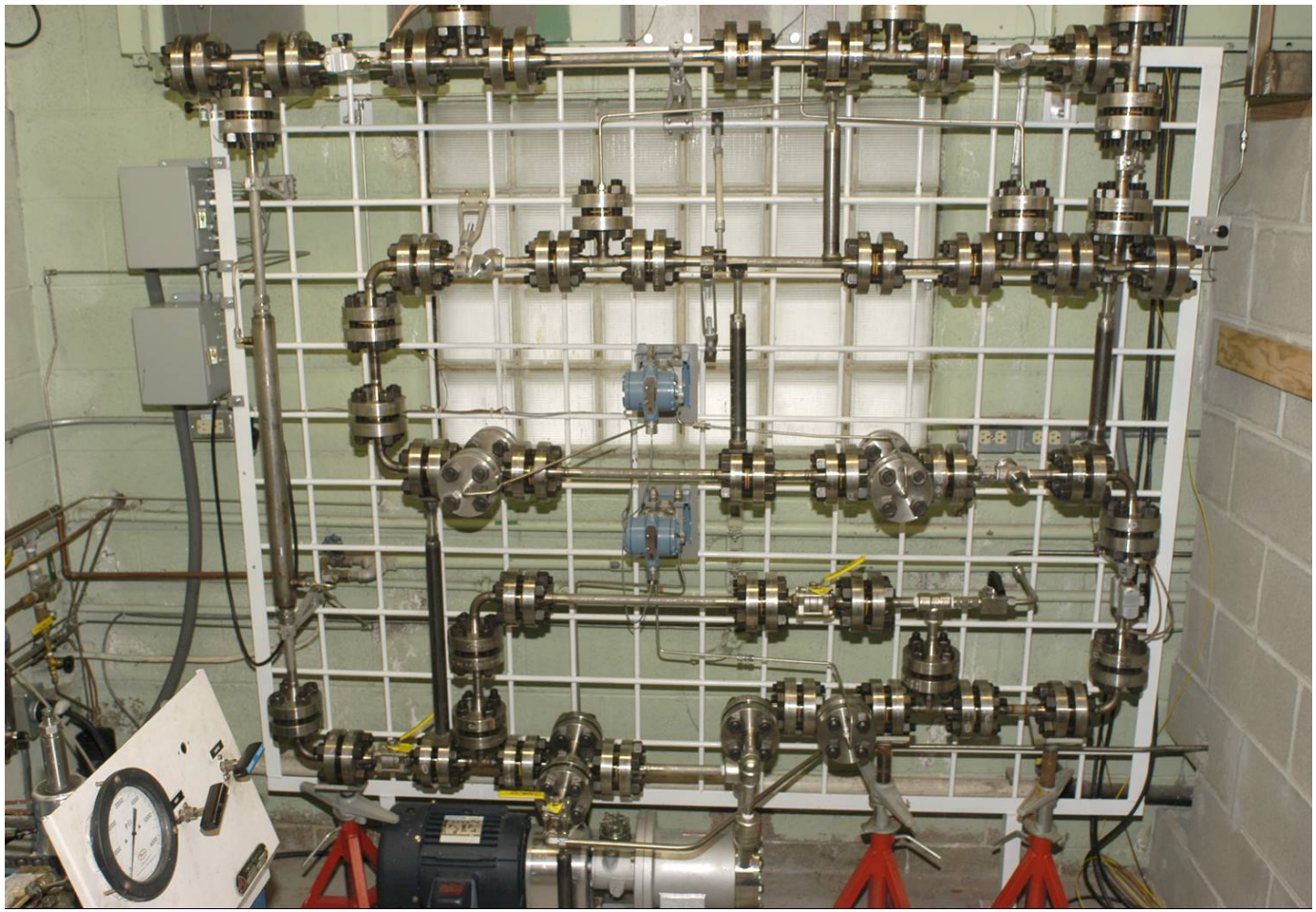
Pump Characteristics

- Magnetic Drive
- 316 SS Casing
- Single-Stage Regenerative Turbine
- Variable-Speed Motor

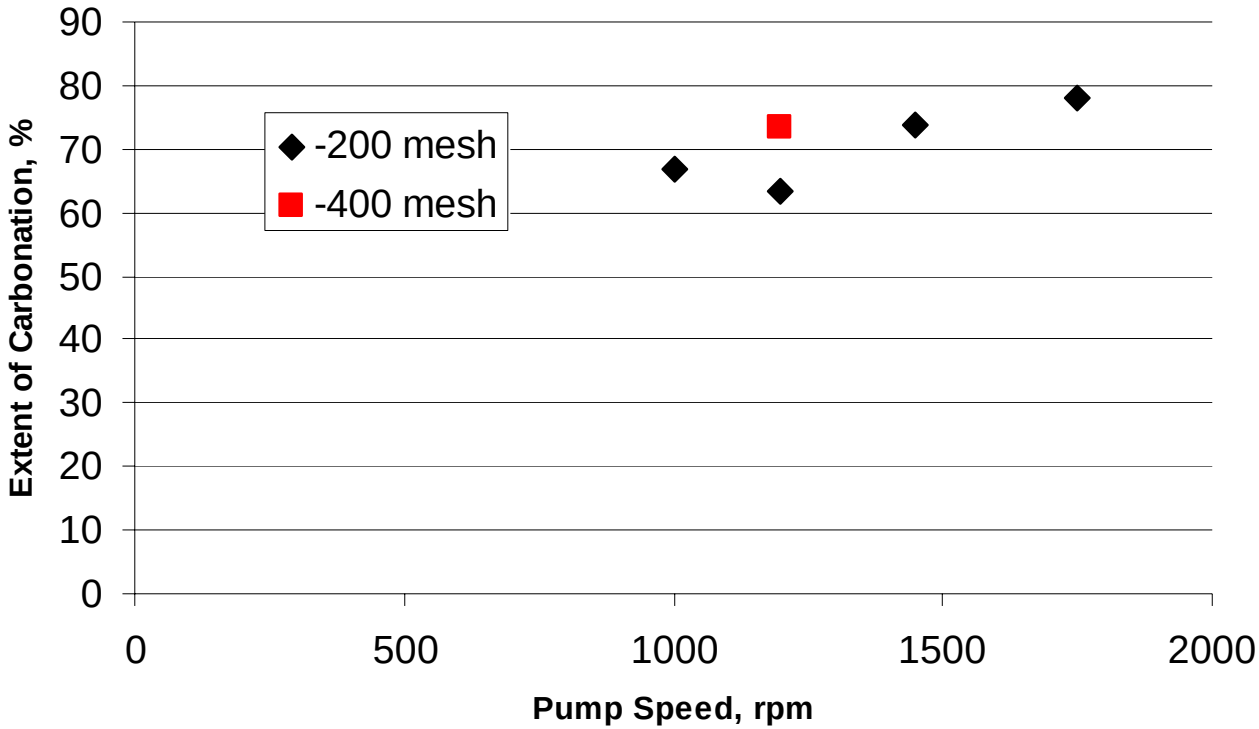
Slurry Pump



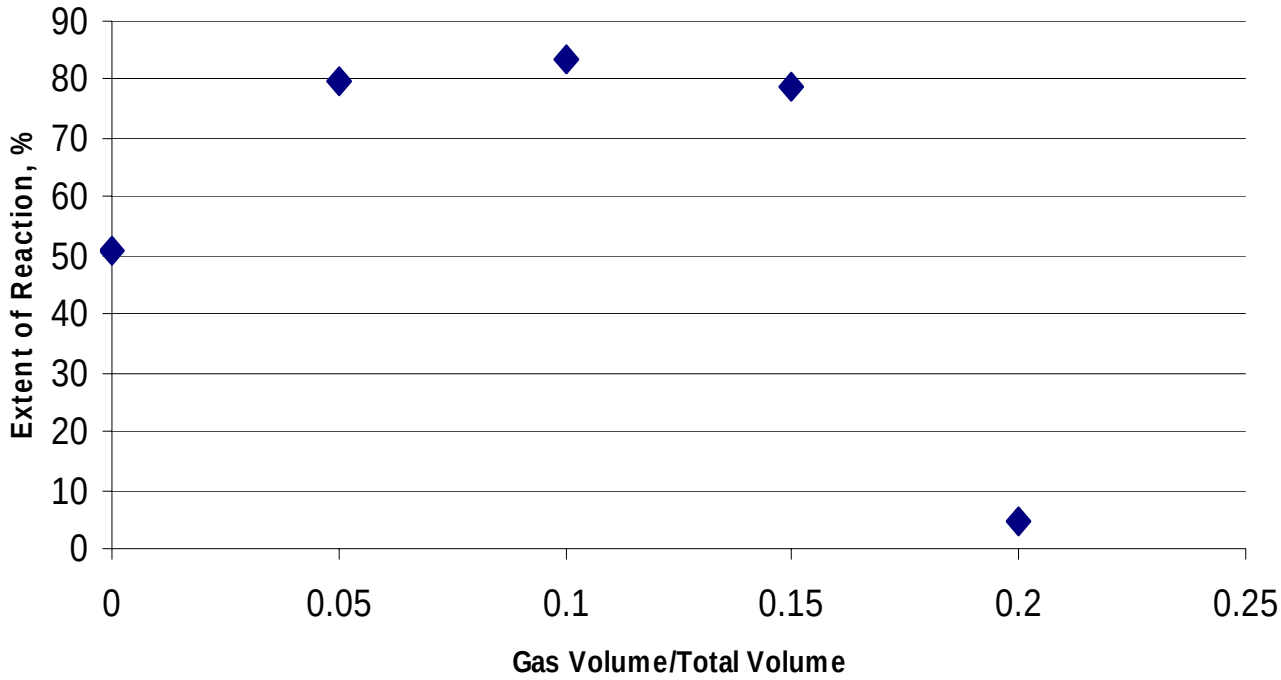
HTHP Flow Loop Reactor



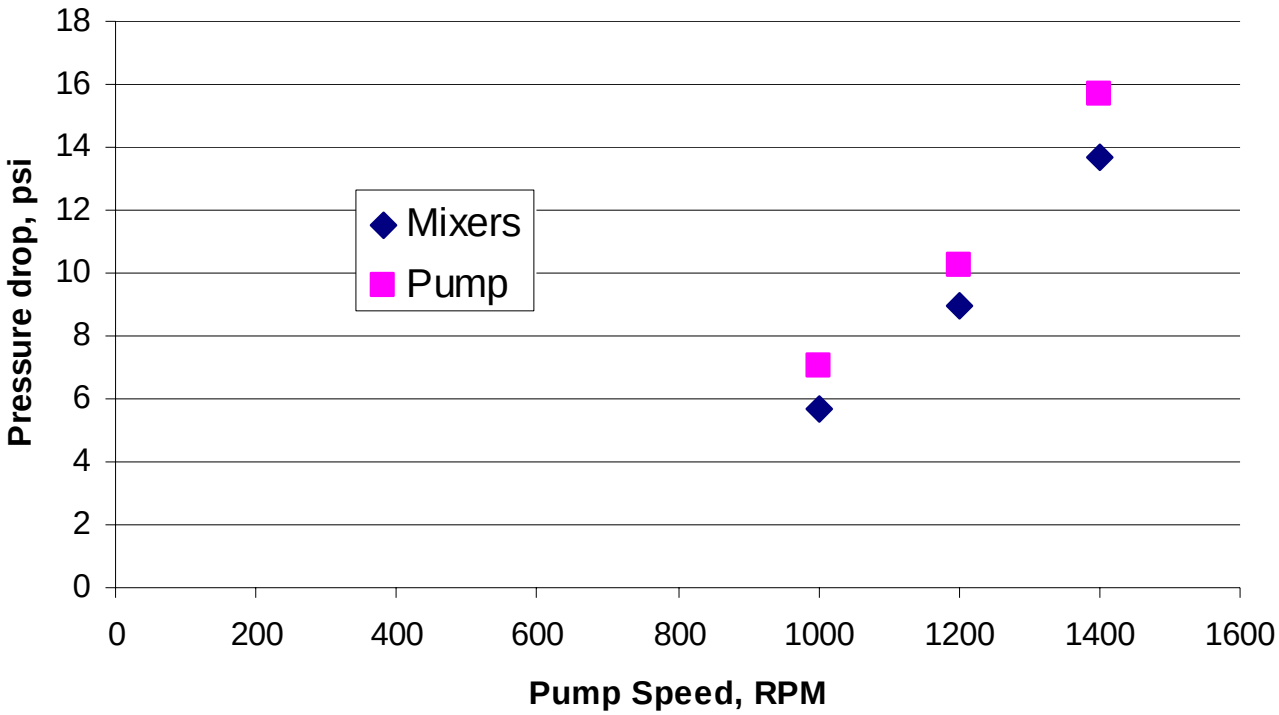
Extent of Reaction



Gas Liquid Ratio



Pressure Drop



Wear and Corrosion

Worn Ball Valve

Worn Ball Seat

New mixer

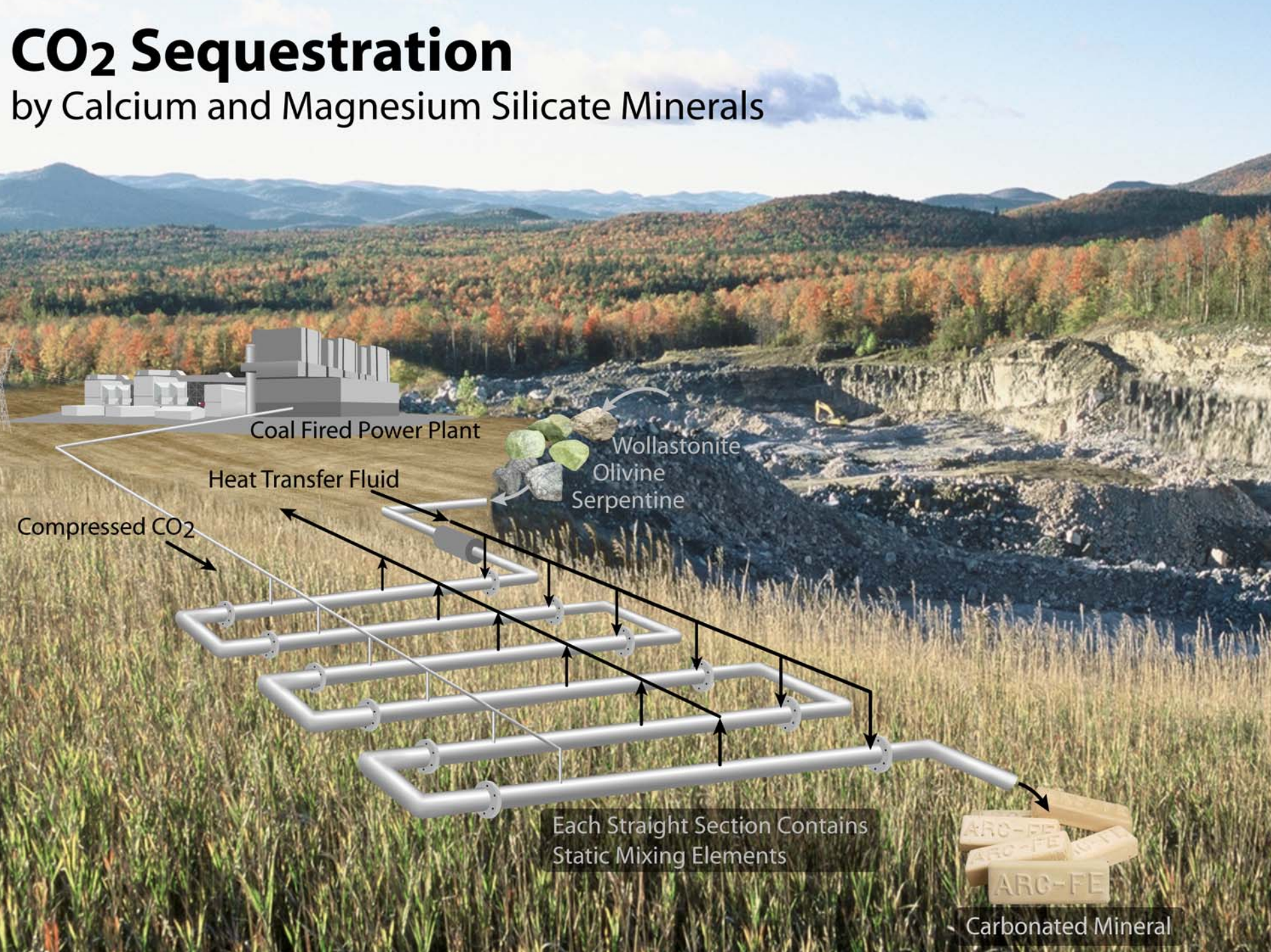
Used Mixer

Conclusions

- Successful operation of high pressure, 3-phase reactor
- Extent of reaction exceed that obtained in batch autoclave tests

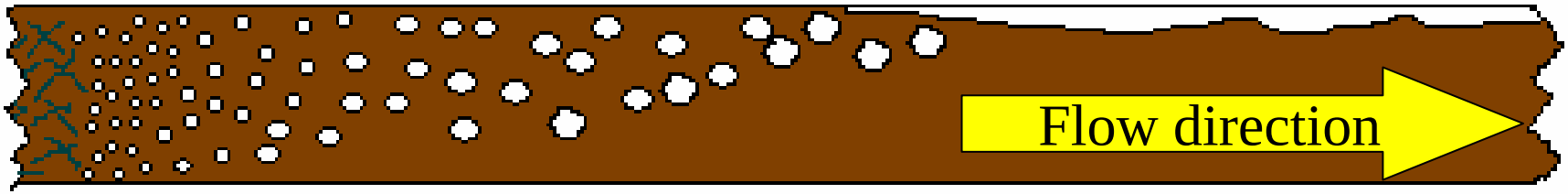
CO_2 Sequestration

by Calcium and Magnesium Silicate Minerals



Small bubbles

CO_2 Blanket



Mixers

Coalescing bubbles